# Non-Invasive Room-Temperature Detection of a Single Trapped Electron in VECC Penning Trap

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**Synopsis** We demonstrate a simple room-temperature method for detecting a single trapped electron without cryogenic electronics or image-current readout. The confined electron ionizes residual gas molecules, producing low-energy ions that are guided to a Microchannel Plate (MCP) and counted individually. These ion bursts provide a sensitive signature of single-electron confinement. Fano-factor analysis and Pearson correlation distinguish the single-electron signal from background and multi-electron conditions, establishing a robust, non-invasive approach to single-electron detection at room temperature.

A non-invasive technique is devised for detecting a single electron confined in a room-temperature Penning trap through ionization of residual background gas. Primary 145 eV electrons are generated using a custom fabricated Carbon-Nanotube-based Electron Gun (CNEG) and loaded by pulsing the upper endcap facing the source, as shown in Figure 1. The electron transit time from the upper to lower endcap, including reflection from the −500 V lower endcap, is around 2–4 ns. Electrons arriving within this window are captured when the upper endcap is switched from 0 to −500 V.

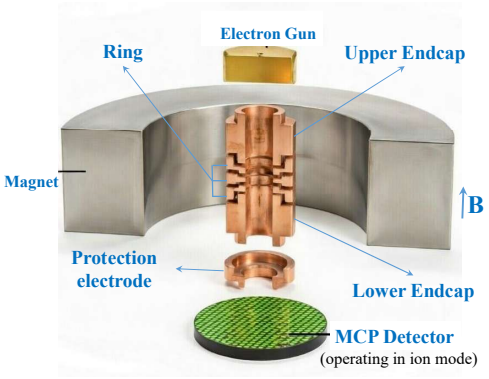


**Figure 1**. VECC Penning Trap assembly

The confined electron ionizes residual gas molecules, producing low-energy ions that are extracted, guided to a MCP by a +300 V ring-electrode potential and detected individually. Background measurements of ion hit pattern over 500 cycles of 100 milli-seconds each gave a Fano factor near unity and a Pearson coefficient of 0.14, indicating predominantly random ionization [1]. When CNEG was biased to −145 V, corresponding to 0.5–1 electron per micro-second, the Fano factor increased to 1.42 and the Pearson coefficient to 0.24, indicating a common electron-induced ion source. Higher CNEG voltages produced more than two stored electrons, yielding a Fano factor of 1.7 and a Pearson coefficient of 0.01, respectively, while lower voltages reproduced background statistics. These results demonstrate single-electron confinement through statistical ion detection and provide a practical room-temperature alternative to conventional cryogenic image-current detection [2, 3]. Beyond direct detection, this technique provides a potential pathway toward developing a high-fidelity single-electron source, which could enable sensitive charge and force measurements, precision sensing, and emerging quantum-information technologies requiring controlled single-electron generation and manipulation.

## References

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